2013 Seawater Intrusion Assessment

City of Bainbridge Island
Groundwater Management Program

This is a provisional examination of chloride concentration in groundwater measured by the City's Groundwater Management Program (GMP) to assess potential for seawater intrusion into the City's drinking water supply. The concentration of chloride (chlorine ion) is used as the indicator parameter for seawater intrusion. Chloride is nonreactive and is not easily adsorbed onto the grains of sediment that make up the aquifer, meaning it tends to stay dissolved and accumulate in groundwater.

Through the use of Early Warning Levels (EWLs), the City is able to identify potential developing impacts for further investigation. The EWL for chloride concentration is at or above 100 mg/L (based on Ecology's draft *Seawater Intrusion Policy*, Washington DOE, 1990) or any increasing trend in chloride concentration. **However, specific determination of seawater intrusion requires additional confirmation monitoring in any suspect areas.**

In 2013, the City collected chloride samples from 28 private and public wells Island wide from aquifers most vulnerable to seawater intrusion or in wells in close proximity to the shoreline (< ½ mile). Chloride concentrations measured by the GMP since 2008 are summarized by aquifer for both dry season and wet season in Tables 1 and 2 below, along with limited data from the City's Water Utility and the Kitsap Public Utility District (KPUD) (source: Martin Sebren, KPUD Hydrogeologist). All of the wells monitored fell below the Island's background chloride concentration of 30 mg/L, and no wells exceeded the chloride screening level of 100 mg/L.

Table 1. Summary of Dry Season Chloride Concentration by Aquifer (mg/L)									
Aquifer	2008			2012			2013		
	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
Perched	Not Sampled			5.82	10.40	3.28	6.41	11.10	3.71
Semi-Perched				5.81	6.04	5.58	5.69	6.73	3.18
Sea Level	8.30	11.00	5.60	4.89	13.60	2.08	5.68	13.20	2.23
Galciomarine	Not Sampled			3.57	5.39	2.55	4.62	6.76	2.79
Fletcher Bay	7.30	7.30	7.30	7.51	7.51	7.51	20.30	24.00	16.60

Table 2. Summary of Wet Season Chloride Concentration by Aquifer (mg/L)									
Aquifer	2008			2012			2013		
	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
Perched	3.70	4.50	2.50	Not Sampled			Not Sampled		
Semi-Perched	5.25	6.00	4.50						
Sea Level	3.09	5.69	2.00	8.79	12.60	5.34	8.59	11.70	5.72
Galciomarine	2.67	4.00	2.00	Not Sampled			Not Sampled		
Fletcher Bay	8.73	9.48	7.97	8.23	9.75	6.70	8.12	9.65	6.59

Chloride concentrations since 2008 are listed by aquifer for each well monitored in Tables 3 and 4 (pages 6 and 7). Please note that the typical accuracy of the laboratory method, EPA 300.0, for chloride analysis is generally ± 20%. Therefore, only a concentration > 20% higher than the previous measurement are deemed to be an "increase."

Sampling data from the Perched, Semi-perched, Glaciomarine, and Fletcher Bay aquifers show no apparent indication of seawater intrusion. All concentrations measured were well below the screening level and showed no increasing trend since 2008. The same can be said for the Sea Level aquifer with two localized exceptions.

Although chloride concentration was well below the screening level of 100 mg/L for one private well located near Fletcher Bay, the concentration increased slightly between 2012 and 2013. However, **confirmation of an increasing trend requires at least 4 consecutive samples with increasing concentrations or samples taken over at least a 1-year period with seasonality taken into account.** Further monitoring is necessary to determine if concentrations in this well is increasing.

The second local exception is a KPUD production well (North Bainbridge #7) that showed an increase between 2008 and 2012. Increasing chloride concentration in this well was first identified by the City in the *Groundwater Monitoring Program – Program Update* (December 2008, revised March 2009) which can be found on the City's webpage in the GMP library at

http://www.bainbridgewa.gov/175/Groundwater-Monitoring-Program. The following is an excerpt from page B-2 of the document.

Chloride levels in Well 7 have shown a slight but erratic increase from 2003 through 2006 (8 to 11 mg/L). Although values are low and pumping levels are generally above sea level, the trend suggests that chloride levels in this well should continue to be monitored and assessed periodically.

Although overall concentration remains low (<14 mg/L), continued monitoring is warranted to ensure that this is not a developing issue.

If an increasing trend is confirmed, appropriate management responses will be implemented as detailed in the following excerpt from the City's *Groundwater Monitoring Program – Program Update* (December 2008, revised March 2009). This document in its entirety can be found on the City's webpage in the GMP library at http://www.bainbridgewa.gov/175/Groundwater-Monitoring-Program.

4 Early Warning Levels and Management Responses

4.1 Overview

For the purpose of the GMP, an EWL is a monitoring criteria that, if exceeded, would result in appropriate Management Reponses. Responses would be of two types: (1) additional investigations in order to determine if a potential problem is developing, and (2) protective or remedial actions where appropriate. Possible investigations could include additional data evaluation, expanded monitoring, problem specific technical review and analysis , or modeling. Possible actions may include water conservation, limitations on new wells, or development of alternate water supplies.

The purpose of specifying EWLs is to provide quantifiable measures for initial evaluation of data that will provide timely warning of a developing issue before a problem becomes acute. Provisional Early Warning Levels were developed in the initial Groundwater Management Program report (Aspect, 2006b) and are modified below. The reader is referred to the 2006 report for additional information on the development of provisional EWLs.

The purpose of Management Responses is to provide the City with a structure of appropriate and sequential monitoring and investigative activities that would lead, if necessary, to protective or remedial actions. The emphasis at this time is on the monitoring and investigative activities.

4.2 Early Warning Levels

4.2.1 Seawater Intrusion

The concentration of chloride (chlorine ion) is used as the indicator parameter for seawater intrusion because chloride is nonreactive and is not easily adsorbed onto the aquifer matrix. Background levels of chloride in groundwater on Bainbridge Island are still being evaluated, but at this time an interim level of 30 mg/L is suggested for data evaluation.

The proposed EWL for sea water intrusion is amended in this report as follows: ***-A chloride concentration at or above 100 mg/L or any increasing trend in chloride concentration****. The 100 mg/L level is based on Ecology's draft Seawater Intrusion Policy (Washington DOE, 1990).*

Trends should be categorized as increasing, stable, decreasing, or undetermined. A determination of increasing or decreasing trend would require at least 4 consecutive samples or samples taken over at least a 1-year period with seasonality taken into account. A stable determination would require examination of data over a 3-year period.

4.3 Management Responses to Exceedances of EWLs

4.3.1 Seawater Intrusion

The purpose of the GMP, with respect to seawater intrusion, is to provide the City with a structure of appropriate monitoring actions for cases where elevated chloride concentrations are observed.

For elevated chloride concentrations, the proposed Management Responses are confirmation, determination of extent, and identification and implementation of actions.

1. Confirmation *is intended to verify the data and reject spurious values. Steps include comparing chloride values with specific conductance readings, increasing frequency of chloride testing to quarterly and inspecting data for seasonality effects. Confirmation should require four consecutive elevated readings over at least a 1-year period.*

2. Determination of extent *requires increased monitoring in order to characterize the nature and extent of elevated readings. New monitoring wells may need to be identified and added to the network. Focused monitoring would initially identify wells between the high chloride well and the coastline and secondarily investigate lateral extent up and down the coast. Collection of metering data, if available, will be useful in future analysis.*

Appropriate analysis is dependent on the situation and may include comparison of well completion elevations and distances from the coast with chloride levels; refinement of hydrogeological interpretations; consultation with purveyors, Ecology, Washington State Department of Health (DOH) and/or Kitsap County Health District; neighborhood interviews; and/or comparison with results of groundwater modeling.

3. Identification and implementation of actions *would be required for situations where confirmation and determination of extent indicate seawater intrusion is occurring. Remedial measures would be defined and recommended as appropriate and in consultation with Washington State DOH, Kitsap*

Health Department and Ecology. In order to protect an aquifer from further degradation, recommended actions may include additional focused monitoring or groundwater modeling, water metering, water conservation, limitations on well drilling, development of system interties, or development of alternate water supplies.

Table 3. Dry Season Chloride Concentration								
Aquifer	2008		2012			2013		
	Date	Chloride (mg/L)	Date	Chloride (mg/L)	Increase?*	Date	Chloride (mg/L)	Increase?*
Perched								
	Not Sampled		9/11/2012	5.80	N/A	9/9/2013	6.73	no
			9/11/2012	10.40	N/A	9/9/2013	11.10	no
			9/10/2012	3.28	N/A	9/11/2013	3.71	no
			9/11/2012	3.78	N/A	9/9/2013	4.11	no
Semi-Perched								
	Not Sampled		9/11/2012	5.58	N/A	9/11/2013	6.63	no
			9/11/2012	6.04	N/A	9/11/2013	6.73	no
	No Data Available		No Data Available			9/4/2013	6.20	N/A
						9/12/2013	3.18	N/A
Sea Level								
	Not Sampled		9/11/2012	7.73	N/A	9/10/2013	8.07	no
			9/10/2012	2.16	N/A	9/11/2013	2.34	no
			9/11/2012	5.78	N/A	9/9/2013	6.86	no
			9/10/2012	2.59	N/A	9/11/2013	2.93	no
			9/11/2012	2.46	N/A	Not Sampled		
			9/10/2012	2.25	N/A	9/9/2013	2.56	no
			9/10/2012	2.20	N/A	9/12/2013	2.40	no
			9/10/2012	12.70	N/A	9/12/2013	8.06	no
			9/11/2012	4.94	N/A	9/10/2013	5.47	no
			9/11/2012	2.22	N/A	9/10/2013	2.38	no
			9/11/2012	2.66	N/A	9/11/2013	2.86	no
			9/10/2012	2.08	N/A	9/2/2013	2.23	no
			9/11/2012	3.86	N/A	9/11/2013	4.05	no
			9/11/2012	2.81	N/A	9/9/2013	2.88	no
			9/10/2012	2.40	N/A	9/11/2013	2.75	no
			9/10/2012	3.35	N/A	9/11/2013	3.76	no
			9/10/2012	2.71	N/A	Not Sampled		
			9/10/2012	5.77	N/A	9/12/2013	6.18	no
			9/11/2012	3.68	N/A	9/9/2013	3.95	no
			9/10/2012	10.50	N/A	9/9/2013	11.70	no
			9/11/2012	8.59	N/A	9/10/2013	13.20	yes
	10/17/2008	5.6	10/10/2012	5.5	no	No Data Available		
	10/10/2008	11	10/10/2012	13.6	yes			
	No Data Available		No Data Available			9/9/2013	12.1	N/A
						9/9/2013	12.5	N/A
Glaciomarine								
	Not Sampled		9/12/2012	5.39	N/A	9/11/2013	5.85	no
			9/11/2012	2.55	N/A	9/12/2013	2.79	no
	No Data Available		9/10/2012	2.76	N/A	9/11/2013	3.09	no
			No Data Available			9/4/2013	6.76	N/A
Fletcher Bay								
	10/9/2008	7.3	10/10/2012	7.51	no	No Data Available		
	No Data Available		No Data Available			9/4/2013	16.6	N/A
						9/4/2013	24	N/A

*Laboratory reported an analytical method accuracy of ±20%. Therefore, to qualify as an "increase" in concentration over the previous measurement, concentration must be over 20% greater than the previous measurement.

Table 4. Wet Season Chloride Concentration								
Aquifer	2008		2012			2013		
	Date	Chloride (mg/L)	Date	Chloride (mg/L)	Increase?*	Date	Chloride (mg/L)	Increase?*
Perched								
	1/15/2008	4.5	Not Sampled			Not Sampled		
	1/15/2008	5						
	1/16/2008	2.5						
	1/15/2008	2.8						
Semi-Perched								
	1/17/2008	6	Not Sampled			Not Sampled		
	1/15/2008	4.5						
Sea Level								
	1/16/2008	4.5	Not Sampled			Not Sampled		
	1/15/2008	2						
	1/15/2008	4.5						
	1/17/2008	2						
	1/16/2008	2						
	1/16/2008	2						
	1/17/2008	2						
	1/15/2008	3.6						
	1/16/2008	3.6						
	1/16/2008	2.1						
	1/16/2008	2						
	1/16/2008	2						
	1/15/2008	2.7						
	1/16/2008	2.1						
	1/16/2008	2						
	1/15/2008	2.2						
	1/16/2008	2						
	1/16/2008	4						
	1/16/2008	2.9						
	1/16/2008	6						
	1/16/2008	6						
	4/3/2008	5.69	4/6/2012	5.34	no	4/5/2013	5.72	no
	No Data Available		4/6/2012	12.6	N/A	4/5/2013	11.7	no
			5/29/2012	8.42	N/A	6/4/2013	8.36	no
Glaciomarine								
	1/15/2008	4	Not Sampled			Not Sampled		
	1/15/2008	2						
	1/16/2008	2						
Fletcher Bay								
	4/3/2008	7.97	4/6/2012	6.7	no	4/4/2013	6.59	no
	5/13/2008	9.48	5/22/2012	9.75	no	6/11/2013	9.65	no

*Laboratory reported an analytical method accuracy of ±20%. Therefore, to qualify as an "increase" in concentration over the previous measurement, concentration must be over 20% greater than the previous measurement.